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# Exploring the potential of Web 2.0 to improve knowledge directories and "group mind"

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## *Abstract*

In this paper we examine how the use of Web 2.0 tools (such as Wikis, Blogs, Social Networking) might provide a digital foundation for a Transactive Memory System (TMS). TMS facilitate knowledge sharing and retrieval processes in groups by the use of a well-maintained knowledge directory. The theory of TMS explains how it is that a group appears to have a "group mind" and research shows that a well functioning TMS improves group performance. Web 2.0 software embeds data about authors, interested parties and related information into the content created in these tools, constituting essentially a knowledge directory which can be used to locate knowledge seekers or advise them of content they may be interested in. Consequently, the use of Web 2.0 tools may improve knowledge absorption and utilisation by supporting TMS. This is a conceptual paper, which seeks to provide a link between Web 2.0 and TMS and, by implication, enhancement in the functioning of groups and organisations.

## *Keywords*

transactive memory systems, TMS, social software, Web 2.0, collective learning, knowledge sharing, knowledge management

# 1. Introduction

Web 2.0 software is a term coined to describe the generation of Internet tools, such as wikis; blogs; social networking services; photo, video and other resource sharing networks; and social tagging which have emerged in the past ten or fifteen years (O'Reilly, 2005; Shuen, 2008). Rather than passive browsing and reading of content placed on the World Wide Web by others (the so-called Web 1.0 environment), new forms of interactivity and participation define the Web 2.0 era. Popular, public uses of the tools are well known, with frequent reports in the media about social networking services such as Facebook, wikis such as Wikipedia, video sharing services such as YouTube, and so on. Businesses and other organisations increasingly participate in public Web 2.0 forums and introduce Web 2.0-based services designed primarily for marketing purposes. In a marketing context, where "Web 1.0" offered a shop front, a product catalogue and secure payment gateway, "Web 2.0" offers customer reviews, ratings and categorisation of products by customers and suggestions for new services and products. Internet vendors even make their programming interfaces available so that other websites can transparently sell their products using a different shopfront (Tapscott & Williams, 2006). Whilst there has been much interest in their use in customer relations and marketing, many Web 2.0 tools are also ideally suited for use as communication and collaboration tools within organisations (Bughin & Manyika, 2007) and groups that operate in systems that are not open to the wider World Wide Web. We consider the use of Web 2.0 tools to enhance the functionality of such closed or "private" groups in this paper.

Despite the recommendations of industry experts, consulting firms and think tanks, the adoption of Web 2.0 tools outside the public sphere has not been as rapid as many expect, and the results of their adoption have been mixed. Knowledge focussed, high performing organisations seem to derive greater benefit than others in using them in innovative and open ways (Bughin, Chui, & Miller, 2009). One barrier to organisational implementation seems to be the development of the initial business case. Several surveys show that whilst most organisations demand a business case, a majority of these fail to provide sufficient justification (Frappaolo & Keldsen, 2008). This is surprising, because the costs for the software and training are very modest.

The literature about Web 2.0 presents a long and impressive list of potential gains from using this software. It provides a simple way in which people can share knowledge, without the need to contribute to formal, structured systems (O'Leary, 2009). It supports distributed work, but can reduce the fragmentation caused by e-mails (Bryan & Joyce, 2007). It is believed to match the expectations and inclinations of young workers at the same time as having the potential to capture the deep knowledge which will be lost when the baby boomers retire (Morello, Kyte, & Gomolski, 2007; Rigby, 2008). It has the potential to multiply the connectivity opportunities offered by network dynamics and to improve creativity, problem solving and decision making by allowing simultaneous application of many minds (Sunstein, 2006; Suriwiecki, 2004). In spite of these arguments, however, the business case often still fails to gain traction.

In this paper, we propose a further argument for the implementation of Web 2.0 tools, which is that through the creation of signposts, the use of these tools makes knowledge (in all its forms) more visible, as a natural by-product of use. When used, by a group or in an organisation, every Web 2.0 tool becomes an implicit directory of knowledge by capturing metadata in the course of being used. This metadata includes descriptions of the information which is entered, the author and their contact details, the time of capture, who is interested in

the information and so on. The capabilities of Web 2.0 tools are strikingly similar to the processes that define transactive memory system (TMS). Formally, TMS are human systems which extend the knowledge and cognitive capabilities of individuals and enable couples and groups to access knowledge across a whole system of relationships. A TMS consists of a knowledge directory and a set of processes which use that directory to allocate and retrieve knowledge (Wegner, 1987).There therefore appears to be a striking similarity between the components of TMS and the capabilities of Web 2.0 tools. Because TMS have been shown to significantly improve group task performance, a system that leverages Web 2.0 tools to enhance TMS might be valuable to groups and organisations, particularly if Web 2.0 offers ways to enhance TMS as a simple by-product of its use for everyday purposes.

In this paper, we therefore seek to demonstrate how a system consisting of Web 2.0 components emulates a TMS, and may even constitute a digital TMS. We proceed in steps. First, we explain the nature of TMS and review the literature about the role of TMS in the functioning of groups and organisations. We then describe specific Web 2.0 tools in more detail before developing a conceptual model of how Web 2.0 tools can support human TMS and act as a digital TMS. We finally put the digital TMS model to the test in a brief walkthrough of how one Web 2.0 tool, the MediaWiki wiki software might act as a TMS.

## 2. Transactive memory systems (TMS)

The theory of TMS comes from the area of small group psychology. It deals directly with the concept of "knowledge signposts" (or directories) (Wegner, 1987, 1995; Wegner, Erber, & Raymond, 1991). Whilst originating in research into studies of dyads and small groups, the concept of TMS has been extended to describe knowledge storage and retrieval in organisations. TMS consist of knowledge directories and the processes which are used to maintain and access them within groups. Through knowledge specialisation, members of a group develop specific responsibilities for expertise. When knowledge enters the group, it is allocated to the responsible member. In the process, group members encode into their personal directory structures that a certain expert has certain types or pieces of knowledge, and they subsequently retrieve that piece of knowledge from the expert responsible for that general area if and when they need it. The three processes of a TMS can be summarised as directory maintenance, allocation of knowledge and retrieval of knowledge.

In small groups, like families or couples, responsibility for cooking or repairs might be divided up between husband and wife (respectively): they specialise and information gets allocated to the responsible person (new recipes, a window not closing, a new kind of putty). When a child cooks, they ask the mother for "that new recipe" or where the pots are kept. The members of the group get to know who-knows-what and manage things accordingly. In larger commercial organisations, similar processes occur, although they might be more complicated and the media upon which transactive directories are stored might be a loosely linked network of personal brains, paper, organisation structures and roles, and electronic databases. These media are maintained and used via a variety of modalities: chatting, updating personal pages or going to meetings for example. The key point here is that a well-developed TMS turns personal or local memory into organisational memory by making it findable, available and retrievable. And this is done naturally without having to capture the actual content in some explicit, shareable medium or technology such as a database or "lessons learned" report.

TMS are a form of social cognition which is enabled by information about the characteristics of group knowledge and the associated processes of maintaining and using that metadata to

retrieve and store knowledge. Knowledge which group members have about a particular topic or thing is differentiated (at least conceptually) from knowledge that groups members have about each other. When a group exchanges information about the specific expertise of its members, its TMS facilitates access to expertise when it is needed. Thus, a TMS is characterised by specialisation of expertise, which develops as members of the group differentiate themselves from each other through capability or particular interest. The respective specialists need to be credible in order for the directory to be of any use and the processes which then lead to the knowledge in the group actually being used need to operate in a coordinated fashion.

TMS can be seen as a key component of "group mind" and provide an explanation of how a group can appear to have a collective consciousness, without needing to fall back on telepathy or metaphysics to explain the apparent single-mindedness (Hutchins, 1995). The purposeful and coordinated nature of groups, the patterns and regularities in task execution convey the impression that there is a single organism at work. The information-based TMS approach goes some way to explaining the coordination and consistency in group function whilst remaining solidly materialist. Metadata about group knowledge is collected in group processes (where information is exchanged) and this data is maintained in the personal minds and artefacts of group members. The social nature of these processes means that there will be a general consistency in the content of directories ("We all know that Fred is the expert on project management"), whilst leaving room for personal preferences ("I find Fred difficult to deal with so I won't ask him for advice").

The research shows that a well-developed TMS can decisively improve group capability. In one experiment, a TMS developed through group training improved group performance far more than individual training with team building exercises - good news for those who hate group hugs and just want to do a good job (Moreland, Argote, & Krishnan, 1998; Moreland & Myaskovsky, 2000). There is a strong positive correlation between strength of TMS and knowledge worker team performance (Lewis, 2004). Group performance is believed to reflect the ability of a group with a well functioning TMS to store and recall more knowledge than any individual (Hollingshead & Brandon, 2003), to use the knowledge of others better (Moreland et al., 1998; Stasser, Stewart, & Wittenbaum, 1995), to match problems with the person most likely to resolve them (Moreland & Levine, 1992), to coordinate activities more effectively because of better anticipation of capabilities of others and appropriate allocation of roles and tasks (Wittenbaum, Vaughan, & Stasser, 1998), to make better decisions through the recognition and evaluation of the expertise contributed by group members (Stasser et al., 1995), and to reduce cognitive load when others act as external memory stores and allow greater specialization (Hollingshead & Brandon, 2003; Wegner, 1987).

It is to be expected that a well-functioning TMS will enhance the absorptive capacity of an organisation (Cohen & Levinthal, 1990; Szulanski, 1996). The metadata in the TMS directory and the consistent knowledge classifications which it imposes upon organisational memory give a clear indication of which repository is responsible for certain types of knowledge. When new knowledge enters the group, the directory can be used by the allocation process to transfer the knowledge to the most suitable repository.

## 3. Web 2.0

Web 2.0 is used to describe both a specific type of technology and the way of thinking and working that the technology has enabled. In human terms, Web 2.0 is a mode of participatory

interaction that is mediated by World Wide Web technologies. (The technologies include Web services and other technologies that users typically see in a Web browser, configured in such a way that they form what is called a Web service-oriented architecture.) In contrast to the posthumously baptised Web 1.0, which was based upon a predetermined client-server relationship between consumers and a managed Web site, the Web 2.0 mindset is about interactive, conversational co-production of information, products and, often, one's public image or oneself. Web 2.0 provides a platform of tools for such interaction, rather than a predefined set of rules of engagement and outcomes. The tools can be taken in many directions and applied in many ways. The information content is loosely structured and conversational, in contrast to e-commerce marketplaces or tightly structured knowledge management systems, and so Web 2.0 tools are often called "social software".

The technology tools available under the banner of Web 2.0 can play a substantial role in the creation, exchange and storage of knowledge. They support knowledge creation, interaction and collaboration, networking and sharing. One can use them to mediate interaction between the people within small and large groups, with an organisation's customers, or with business partners, suppliers and vendors. This is not the intended function of these tools, which have their genesis in the role they play in the lives of Web users. It so happens that they have characteristics that make them useful for the management of working knowledge, knowledge which is a key to collaboration and the effective functioning of groups, and a productive resource for the delivery of industrial production or services. Web 2.0 tools, although individually useful, should also be seen as a set of configurable components which, when working together, provide strong functional support for the production and exploitation of knowledge. This platform of tools provides open-ended, highly flexible support for knowledge transformation activities. The key tools that are of interest to us here are:

- *Blog* - A type of Web site often maintained by an individual person and displayed in reverse-chronological order (from newest to oldest). Blogs can contain postings on a theme, event or topic and can include video and image material as well as text. They often include links (*hyperlinks*) to other blogs or sources of information on the World Wide Web. Very short blogs, such as those that contain the brief messages popularised by Twitter, are known as *microblogs*. Whilst blogs are broadcast by the author, blog technology incorporates tools for responding to or commenting on the posted material.

- *Really Simple Syndication (RSS)* - A format for tracking changes to existing Web sites or pages. Once a user has enabled an RSS feed (or Web feed) for a Web site, a Web page, or in some case, for a specific topic, they are notified by changes or updates (including, for example, a new news article or stock price change) via their Web browser or a task-specific RSS feed reader.

- *Social networking service (SNS)* - A Web service which allows people to build communities based upon special interests or personal inclinations and share information with others with whom they form those communities. Each user has their own personal Web page within the service, and that page forms the basis of links to and from other people, resources, gadgets (e.g., software that performs a simple function such as displaying a thumbs up sign) and tools. Well known public SNS are Facebook and MySpace. Public SNS also exist for specific groups or activities; one example is LinkedIn, an SNS that enables people to share information about expertise and professional interests and acts as an online job market.

- *Resource sharing service* – A Web service that enables people to share media such as photographs (e.g., Flickr, Picasa), short films (e.g., YouTube) or music.

- *Wiki* - A type of Web site, managed by wiki software, which allows immediate creation, editing and linking of Web pages. Wikis are usually used for the collaborative creation of content by multiple authors and editors. They provide many functions to improve information management such as security, linking and tagging.

- *Social tagging* - The activity of creating, applying and sharing descriptive metadata (tags or labels) in order to annotate and categorise content in web pages and documents. Tags can be created and shared via social tagging Web sites or using the functions of wikis, blogs or other social software – often with just a click on an icon.

- *Mashup* - A Web page that incorporates content and tools drawn from several sources in order to "mash up" a resource that is more than the sum of its parts. Many mashups overlay content, comment and links on map references, displaying them using a geographical mapping tool such as Google Maps.

- *Discussion forum*, *instant messaging* and *chat* - are all tools that support discussion (often just using text, although conversations might also use or incorporate video) between two or more people. Discussion forums typically record postings made sequentially at different moments in time (i.e., they support asynchronous conversations) whilst instant messaging and chat services are typically associated with real-time (synchronous) conversations. While stand-alone tools are available for each of these services, they are often incorporated within other Web 2.0 tools.

- *Semantic Web* - In contrast to social tagging, this is a vision for enabling Web content to be understood by software through an automated system of formal linked metadata which mirrors underlying conceptualisations of human life and areas of activity. The idea is that this metadata can be used to tag or interpret Web content.

Figure 1 shows how a subset of these Web 2.0 technologies can be combined to deliver a suite of open-ended services to an individual knowledge worker. The worker can adapt these to suit their own purposes: the services are common, general purpose infrastructure and can carry any type of information to any required level of detail or granularity. As configured in Figure 1, these services incorporate (the numbers in this list refer to the arrow in the figure):

1. The manager (or other expert) posts news and notices, expresses opinions and shares expert information via a blog.
2. The knowledge worker reads updates in the blog via RSS.
3. Searching for information and navigating through Web pages taps into the semantic Web which, informed by tagging and other Web 2.0 activities of the knowledge worker and colleagues, finds wiki pages.
4. While searching and navigating, the knowledge worker adds social tags to found resources, helping them – and others – to find the resource in the future.

5. Wiki pages include links to other Web pages and other organisational systems such as document management systems.
6. The knowledge worker creates personalised mashups using tools that adopt service oriented architecture.
7. The personalised mashups are incorporated in the knowledge worker's SNS personal page.
8. SNS (in this case, a private group within the public Facebook service) is used to make the mashups obvious to others in the knowledge worker's network.
9. Notifications of changes (e.g., in wiki pages, other Web pages or documents or other web pages) are delivered to the knowledge worker via RSS.

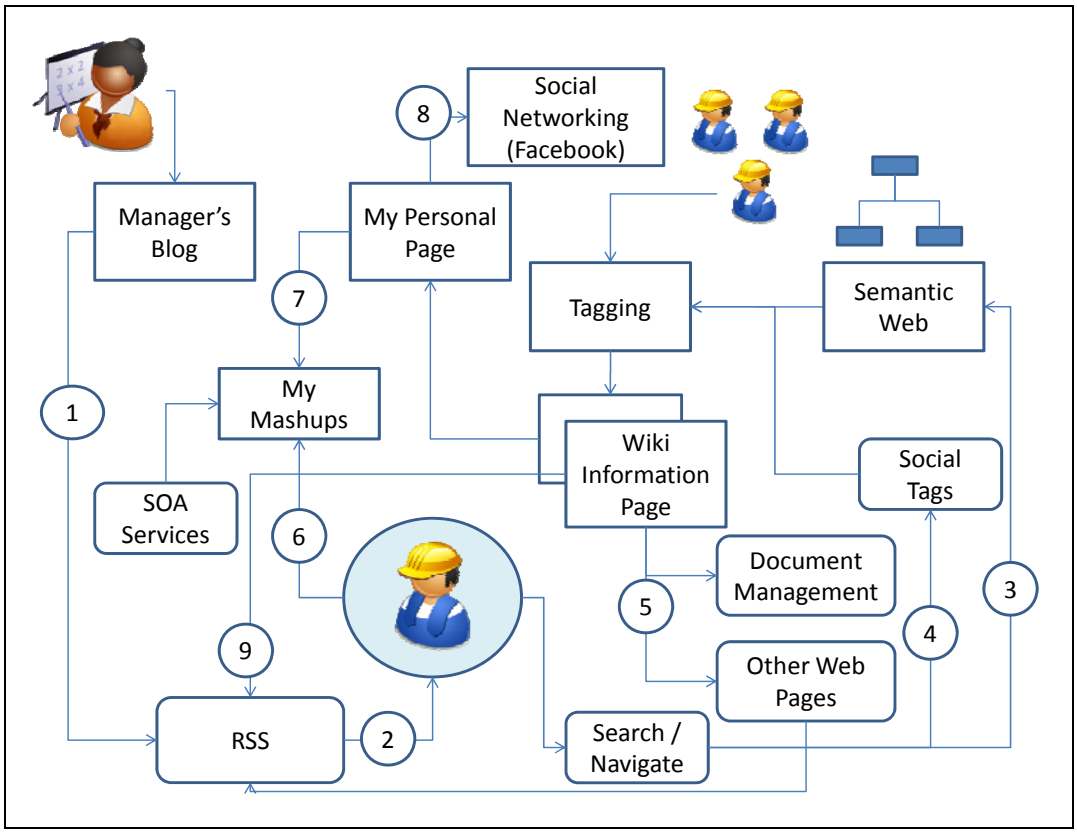


*Figure 1.* Combining Web 2.0 components to create a work system for a knowledge worker embedded in a network

## 4. How Web 2.0 tools support TMS

Transactive directories are maintained automatically or as a by-product of online activity in Web 2.0 systems and are searchable and navigable electronically. In groups where authors' names are known, one can hyperlink from a wiki page to the author's personal page or vice versa. Wiki, blog and SNS entries are searchable based upon the knowledge they contain or can be found by navigating conceptual dictionaries which can be hierarchical or flat lists of terms used to categorise or tag individual pages and resources or derived from semantic indexing. Each editorial change to a wiki, blog or SNS page is linked to a specific, identifiable editor. Editors, as well as authors, may have a personal page describing their contact details,

role, preferences and interests, and prior experience. Each personal page may show links through an SNS to colleagues or "friends" who share similar interests and knowledge (Mueller, 2008). Wiki, blog and SNS pages can be made RSS capable or "watched" for changes, so that individuals or groups can subscribe and be notified of new knowledge entering the system according to their personal watchlists. All this functionality provides direct support for the directory, allocation and retrieval processes of TMS.

TMS can be strongly supported by Web 2.0 technologies which offer directory and link capabilities alongside access to the wide range of information is being digitised and made searchable. Figure 2 illustrates the interaction between the TMS processes and various Web 2.0 capabilities and shows how the key transactive processes of building and maintaining a directory of group knowledge (arrow 1), allocating and distributing new knowledge to the responsible repository (2) and retrieving the knowledge when it is required by using the directory (3), can be supported by Web 2.0 tools.

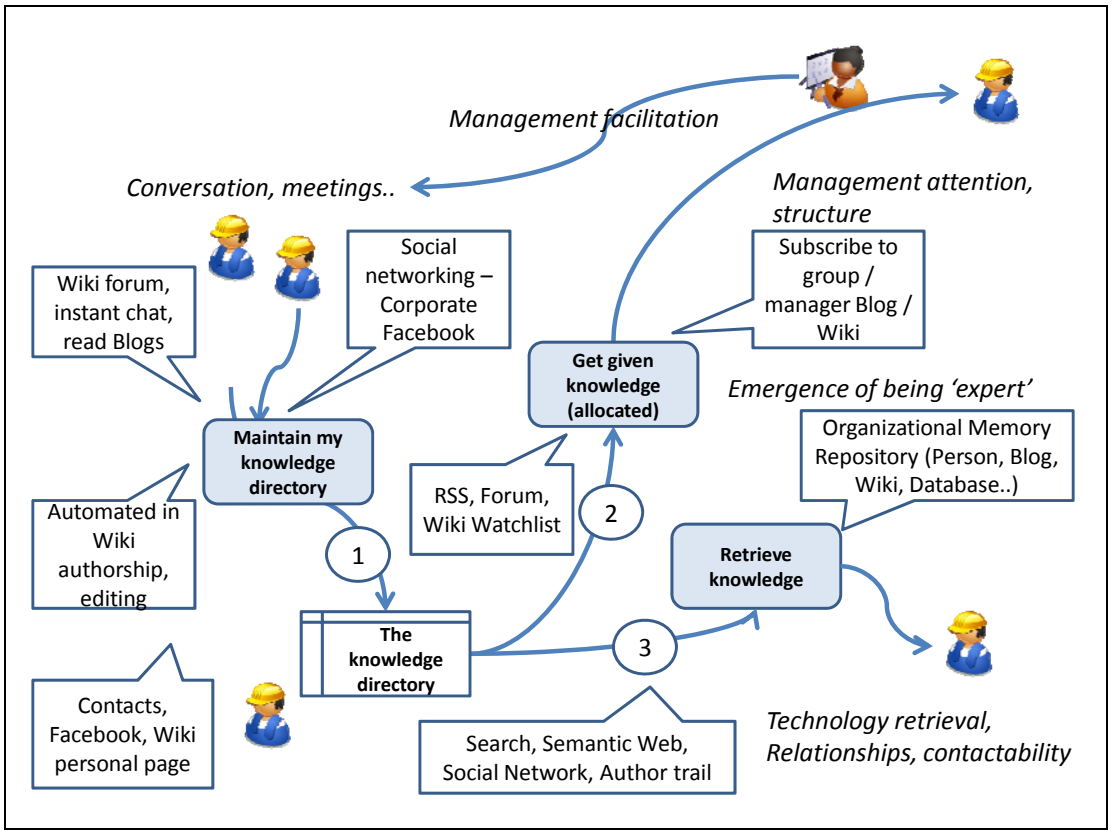


*Figure 2.* Contribution of Web 2.0 tools to TMS processes in an organisation, as seen by a knowledge worker

Figure 2 takes the point of view of a single knowledge worker. The knowledge worker will have their own personal knowledge directory which stores information about expertise and the availability of experts. Although represented in the figure as a database, the knowledge directory draws together knowledge that the worker holds cognitively, in memory, in physical tools such as address lists, electronic tools such as telephone contact lists, and Web 2.0 tools that maintain digital records of the interests and expertise of individuals. What might such a directory contain? Jackson and Klobas (2009) write that in a typical organisation, one expects to find information about roles, areas of knowledge and particular expertise, i.e., where

something might be stored or who might know it. But if that TMS is a personal, mental directory, it might also contain the likeability of the knowledge holder, their real level of competence (not what their resume says), whether they are capable of working in a team and so on. The TMS directory generated in the scenario in Figure 2 contains:

- Links from the content of a wiki page to the contact details of an editor that wiki page;
- Links to the contact details of participants in wiki page discussions;
- Hyperlinks from any page (Wiki, blog or SNS) to any other item of related information;
- Personal information available from the SNS or personal Web pages of other people in the network, which indicates the expertise and preferences and (increasingly nowadays) gives an insight into more personal metadata (football team supported, likes and dislikes, special interests, and so on);
- Links from the knowledge worker's personal SNS page to "friends" and colleagues with whom they work, who may also be able to help track down (or even have) the required knowledge.
- Information about who is interested in particular wiki pages is contained in wiki watchlist data.
- Information about who is interested in particular tags is also contained in wiki watchlist data.

The knowledge directory is a central component of the TMS, enabling and linking the three TMS processes. Thus, directory maintenance in this Web 2.0-supported TMS draws not only on conversations and meetings held face-to-face or electronically with work colleagues, but also on observations about expertise and interest made through participation in SNS, electronic discussion forums and unplanned online chats, and through noting who has authored or written wiki pages and other resources on certain topics. The knowledge worker will also be (formally or informally) allocated responsibility for certain types of knowledge used or needed by the group. Subscriptions to wikis, blogs, discussion groups and other Web resources, along with Web 2.0 alerting tools such as RSS and wiki watchlists, can help the knowledge worker keep up to date and alert others to their role as experts in the areas of interest. The third TMS process, knowledge retrieval, is also supported by the Web 2.0 system. Knowledge can be retrieved directly from other people and from content posted in wikis, blogs, documents, databases and so on. Web 2.0 tools additionally mediate access to the knowledge of other people, for example, by aggregating content, by providing links from one resource to another, and by providing tags and semantic connections that enable identification of resources that are not immediately identified from searches.

# 5. Web 2.0 tools as digital TMS

Figure 3 shows how a Web 2.0 system can act as a digital TMS.

1. It is a digital extension of the transactive directory that indicates where information or knowledge is stored and how it might be accessed.

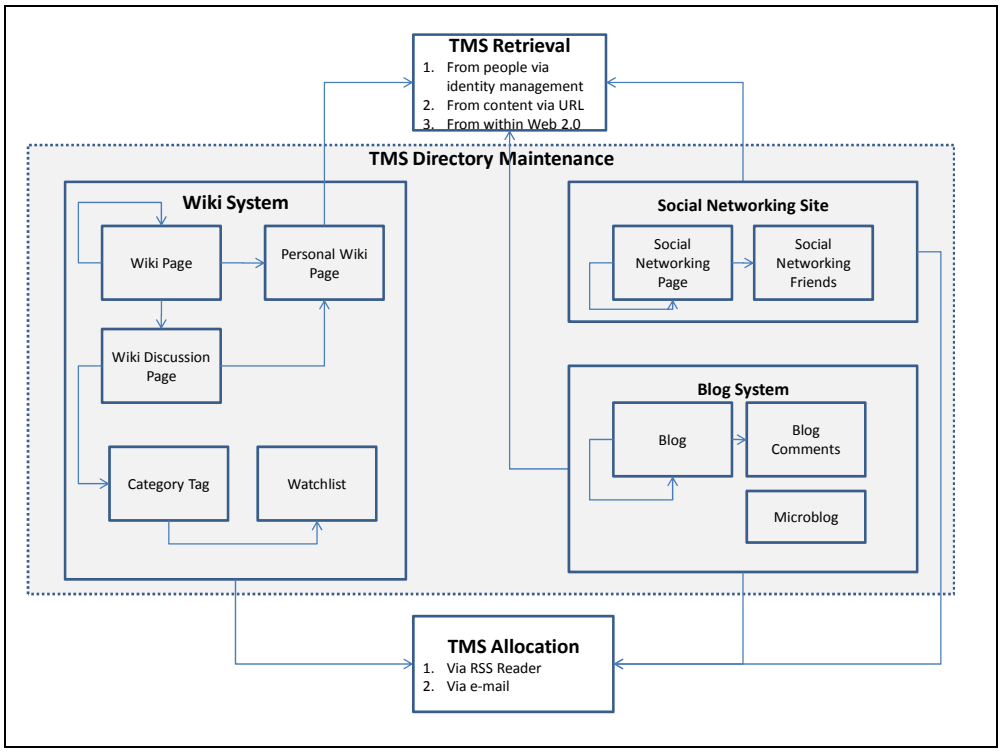


*Figure 3.* How a system of Web 2.0 tools can be a digital TMS

2. It maintains directory information. A typical problem with maintaining organisational directory systems, or "yellow pages" is keeping them up to date (Davenport, 1997; Davenport & Prusak, 1998). In Web 2.0 systems, much of this information is kept as a direct consequence of using the Web 2.0 tools:
   - The identity of wiki page editors is stored with the text of each edit performed and accessible to all subsequent users.
   - The identity of bloggers and commentators on blogs is stored and accessible to all users.
   - Social networking tools, although requiring active input by the user, are also capturing precisely the information which other people require to assess or locate the user.

3. It allocates new information to responsible or interested parties:
   - Within a wiki, the user can activate a "Watch" function, which will cause the wiki to send notifications to the user via e-mail when the page is edited.
   - Within blogs and wikis, the user can subscribe to a page using an RSS reader, which will pick up any changes and new material.
   - Within a wiki, the user can subscribe to a category (or tag) which will allow them to be notified if any pages which are categorised by that tag are changed.
   - Changes to personal networks, including new group members and changes in existing group members' interests and activities, can be sent to members of a group on social networking sites.

4. It facilitates retrieval of information:
    - Information is findable and retrievable via search functions within specific Web 2.0 tools.
    - Social tags allow meaning-based retrieval of information based upon how users classify and tag the information.
    - Information managers (and, potentially in the future, semantic Web technology) allow meaning-based retrieval based upon a standard lexicon (or "ontology") of categories.
    - Hyperlinks from content, tags and terms within an ontology support browsing and navigation beyond pages retrieved in an initial search.
    - A single search function could be overlaid on these mechanisms.

In summary, we see in this section that Web 2.0 tools, when implemented together, comprise a digital TMS which consists of a directory and a set of functions which maintain the directory, allow knowledge to be allocated to others when it enters the system, and facilitate the retrieval of knowledge based upon navigation and search functions. It is possible to move from one directory to another in the process of tracking down information through the system. In the following section, we walk through the wiki software product, MediaWiki, to confirm that TMS directory metadata can be maintained, and examine how this single Web 2.0 tool might facilitate TMS processes.

# 6. MediaWiki as digital TMS

In this section, we move from the general case of a set of Web 2.0 tools to the specific instance of a single tool. Our case is the wiki, a tool evaluated by most enterprises as being useful for internal knowledge management. Specifically, we look at MediaWiki, the software made popular through its use to produce Wikipedia, the 6th most visited Web site in the world[1]. Although not designed for use by private groups, MediaWiki is in use in many organisations[2] including Pfizer, Novell and Intel. MediaWiki is freeware. It is written in PHP and uses the MySQL database, both freeware products. Commercial wikis designed for organisational use are also available, and these offer specific security functions and options for integration with enterprise systems. For this walkthrough, we chose MediaWiki because of its familiarity and because it is sufficiently rich in function to provide a test of the notion of Web 2.0 tools as digital TMS.

## *6.1. The TMS directory*

The TMS directory within MediaWiki consists of data, which when taken together, allows users to track down (retrieve) or be notified of (allocated) information when it enters the wiki system. It is important to note that this TMS directory is an abstraction, much as described by Wegner in his original work: it is not necessarily a single "table of contents", but a set of linked signposts and pointers which have an overall coherence.

In general, the most likely metadata candidates for a TMS directory (taken from Nevo and Wand (2005) and Jackson and Klobas (2008)) and include data about:

[1] http://www.alexa.com/topsites
[2] http://www.mediawiki.org/wiki/Sites_using_MediaWiki/corporate

- The set of named or nameable concepts which describe what counts as knowledge in the system;
- The source or repository of the knowledge; and
- Characteristics of the repository such as field of knowledge, nature of expertise, medium (human, wiki page, etc.), location, qualities such as extent to which it is current or up to date, and so on.

In MediaWiki, data is stored in a MySQL database, which consists of about 40 separate data tables[3]. Within the MediaWiki database, information about TMS directory entries is stored as:

- Concept information - category titles, category pages, and links to other categories;
- User information - user login identification, real name, and e-mail address;
- Links between concept information, user information and content which make it possible to track, for example, from a page of content, to the matching tag or classifying category, to the particular user who is interested and watches that category or page or who defined that concept in the first place.

## 6.2. Transactive directory maintenance

Directory maintenance needs to be triggered by a human action. Where in non-digital social groups this updating might be done in conversations, meetings or by direct observation, in a digital TMS a software function is required. Any time anyone in the system authors, edits, adds a category to a page or establishes a watchlist, the MediaWiki database, and thus the directory metadata, is updated with connections between individuals, content, interests and expertise. Furthermore, updates to the database automatically extend the directory to the deep and rich network of knowledge provided by hyperlinks within the wiki, and across tags and categories. In contrast to conventional corporate “yellowpages” functions, this updating takes place automatically. Further, it is persistent and available beyond the boundaries of an individual or specific social group. Not only does this information provide a direct link to a particular person who may be interested in a particular theme, or who wrote a certain page on a certain subject, the metadata can be easily aggregated to show the amount of activity by a certain person on that page and the relationships between people and pages. In effect, this aggregation creates further directory metadata which is of further use to other transactive processes.

## 6.3. Transactive allocation

The crucial aspect of transactive allocation is that knowledge will be routed to the appropriate person or target (this could be another system or Web 2.0 tool for example) when it enters the system, based upon the interests, specialisation or responsibilities of members of the group or organisation. This is done on the basis of the information stored in the directory.

MediaWiki is most effective when the responsible person uses the software to alert them to new knowledge entering the system and changes to existing information. Tools available in MediaWiki to support this kind of transactive allocation of knowledge are:

[3] http://www.mediawiki.org/wiki/Manual:Database_layout

- Watch a page - By clicking on the Watchlist tab, the user will be informed via their e-mail of changes to the page.
- Watch a category - This is an extension to the MediaWiki software (Extension:CategoryWatch) which allows a user to be informed if any pages which belong to a selected category are changed. It is particularly valuable for transactive knowledge allocation because it allows a person to monitor activity in an area of interest, rather than a particular page.
- Subscribe via RSS feed - It is possible to subscribe an RSS feed reader to the change history of any page in MediaWiki or any change anywhere in the wiki (Special:Recentchanges), such that it will pick up and notify the user of changes to the history page. The feed reader is notified that a change has occurred and the user can go and see what has changed.
- Subscribe to an RSS feeder - This is a MediaWiki extension which allows a user to create an RSS feed on a page and place announcements or information there. So, one might create a page about a certain topic like “Machine Maintenance” or “This Week’s Events”. They can then use special tags to define RSS headers which will be picked up by RSS readers that subscribe to that page

It is possible for one person to assign responsibility to another using a MediaWiki extension (Extension:WhoIsWatching) which allows a user (for example a manager or administrator) to add other users to a watchlist for a page. This extension also allows the user to see who else is watching and therefore interested in, a certain page.

Like directory maintenance, then, allocation is triggered by human action and enhanced by the tracking and alerting functions of the MediaWiki software and its extensions. There is sufficient metadata information in the MediaWiki database to support the automated routing of information entering the system to interested parties. This routing can be on the basis of a category (i.e., a tag) or a particular wiki article. It is necessary to manually add the notification target, but once this is done, notification is automatic. As dates are assigned to actions, extensions to MediaWiki offer automated retention schedules that flag information as dated (for example, after a certain date), so testing for currency or flagging dated information does not need to be an entirely human function.

## *6.4. Transactive retrieval*

The following MediaWiki functions use the directory to assist users to retrieve information:

- Search - This is the most usual and obvious process. The search can run over all text pages stored in the MediaWiki system, in fact the searcher can choose whether to search user, content or category pages.
- Listing - One can simply obtain lists of pages:
  - List all pages: will enable the user to visually scan a results list.
  - List all category pages: the category page displays all the pages, images, video and other resources that have been classified as belonging to the selected category. If a hierarchy of categories or ontology has been implemented in the wiki system, the page also displays all categories belonging to the category, and these in turn can be clicked to get to a related category page.

- Following hyperlinks - Just like other Web- or browser-based pages, links within a MediaWiki wiki lead to related content. Links within MediaWiki can link to information and knowledge repositories outside the wiki. For example, one can link directly to documents in content management systems, Web pages or an organisation's ERP system.

Search and navigation are human functions, but MediaWiki provides the kinds of aids that users expect when they search for a specific resource or on a topic, and when they navigate through a chain of links to find information that does not appear in an initial search result. Ontologies can be established in the wiki by information managers to assist searches by alerting them to relationships between categories that are defined or known to exist in the context in which the wiki has been established.

### *6.5. Summary: MediaWiki and TMS*

In summary, MediaWiki delivers the substantive externalisable components of a TMS. There is sufficient metadata present to constitute a functional TMS directory. This directory is maintained for the most part automatically, and it can be extended manually by users who are interested and motivated. Allocation of new and changed information happens through user-activated watchlists and RSS readers on content and tags, and it is possible for one person to allocate responsibility for an area of knowledge to others. Information retrieval takes place over the directory by searching text and tags, by navigation of linked tags, or by following hyper links to content in the wiki or indeed other information systems. In these ways, MediaWiki provides the digital TMS infrastructure for a group to specialise and develop deep expertise, and yet be aware of and have access to the knowledge of others. As demonstrated previously, this has been shown to improve group and organisational performance.

MediaWiki is not, however, a completely automated TMS. Its TMS functions must be triggered by human actions. In this sense, MediaWiki might appear to suffer from the problems of structured knowledge management systems which are successful only when their potential users are prepared to devote time and effort to adding information to the database. The differences are, however, profound. The actions that trigger the TMS functions of MediaWiki are the natural actions of a knowledge worker who seeks information about their field of interest and makes an effort to keep up to date. It is not necessary for a person to add information to the wiki for their actions to contribute to the wiki's function as a TMS (although doing so further strengthens the TMS): every action that is taken within the wiki strengthens the links between users and content that form the TMS directory.

## 7. Conclusion

TMS is an information processing approach to group mind: it does not describe the role of culture, motivation or personality on group cognition. It explains how a group can appear to function as though it is a single neurological entity, storing information in the appropriate place and retrieving it when it is required. Web 2.0 tools, when implemented as a group or individually, as we have demonstrated with MediaWiki, directly support TMS. The advantages of such visibility and signposting have been a cornerstone of the knowledge management literature, but measurements performed in research into group psychology have demonstrated significant performance improvements from TMS. By extension, the TMS in Web 2.0 tools used within groups (including organisations), should contribute to the performance of these groups. However, other factors will clearly influence the effectiveness

of the TMS. The creation and maintenance of a useful TMS directory will be determined by the actual level of use of the Web 2.0 tools, which may be constrained by the availability of time, technology, physical separation, reluctance for one's activities and interests to be made transparent to others, opportunities for disclosure and so on. The motivation to maintain this directory will depend upon group culture (organisational culture, in an organisation), personal desire, supportive institutions, trust, rewards, and so on. There will be similar influences upon the effectiveness of the processes of information allocation and information retrieval. Research is required to understand how these issues, which are well-known in the knowledge management literature, affect the way individuals act with the more natural and increasingly more familiar tools offered by Web 2.0. Issues of privacy and disclosure that are of significance in understanding how people interact with one another when using public Web 2.0 tools are likely to be important in private Web 2.0 systems. Research is also required to confirm that proposed improvements in performance can be identified, to describe and measure performance effects and to understand the conditions under which group TMS and group performance might improve when assisted by Web 2.0 digital TMS tools. Nevertheless, the implication of the conceptual analysis presented here is that, if the systems are used naturally and as part of daily life, they will improve the performance of "group mind".

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## References

Bryan, L. B., & Joyce, C. I. (2007). *Mobilizing Minds*. New York: McGraw-Hill.

Bughin, J., Chui, M., & Miller, A. (2009). How companies are benefiting from Web 2.0 [Electronic Version]. *The McKinsey Quarterly*. Retrieved 11th November 2009 from http://www.mckinseyquarterly.com.

Bughin, J., & Manyika, J. (2007). How businesses are using Web 2.0: A McKinsey global survey [Electronic Version]. *The McKinsey Quarterly*. Retrieved 11th November 2009 from http://www.mckinseyquarterly.com.

Cohen, W. M., & Levinthal, D. A. (1990). Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly, 35*, 128-152.

Davenport, T. (1997). *Information Ecology: Mastering the Information and Technology Environment*. Oxford: Oxford University Press.

Davenport, T., & Prusak, L. (1998). *Working Knowledge: How Organizations Manage What They Know*: Harvard Business School.

Frappaolo, C., & Keldsen, D. (2008). *Enterprise 2.0: Agile, Emergent & Integrated*. Silver Spring, MD: AIIM - The ECM Association.

Hollingshead, A. B., & Brandon, D. (2003). Potential benefits of communication in transactive memory systems. *Human Communication Research, 29*(4), 607-615.

Hutchins, E. (1995). *Cognition in the Wild*. Cambridge, Mass: The MIT Press.

Jackson, P., & Klobas, J. (2008). Transactive memory systems in organizations: Implications for knowledge directories. *Decision Support Systems, 44*(2), 409-424.

Lewis, K. (2004). Knowledge and performance in knowledge-worker teams: A longitudinal study of transactive memory systems. *Management Science, 50*(11), 1519-1533.

Moreland, R. L., Argote, L., & Krishnan, R. (1998). Training people to work in groups. In R. S. Tindale, L. Heath, J. Edwards, E. Posavac, F. B. Bryant, Y. Suarez-Balcazar, E.

Henderson-King & J. Myers (Eds.), *Theory and Research in Small Groups* (pp. 36-60). New York: Plenum.

Moreland, R. L., & Levine, J. M. (1992). Problem identification by groups. In S. Worchel, W. Wood & J. A. Simpson (Eds.), *Group process and productivity* (pp. 17-47). Newbury Park, CA: Sage.

Moreland, R. L., & Myaskovsky, L. (2000). Exploring the performance benefits of group training: Transactive memory or improved communication? *Organizational Behavior and Human Decision Processes, 82*(1, May), 117-133.

Morello, D., Kyte, A., & Gomolski, B. (2007). *The Quest for Talent: You Ain't Seen Nothing Yet* (No. G00153872). Stamford, CT: Gartner Inc.

Mueller, C. (2008). Analyse sozialer Informationsraeume zur Foerdernug des selbstorganisierten Wissensmanagement. In P. Alpar & S. Blaschke (Eds.), *Web 2.0 - Eine empirische Bestandsaufnahme* (pp. 159-181). Wiesbaden: Vieweg+Teubner.

Nevo, D., & Wand, Y. (2005). Organizational memory information systems: a transactive memory approach. *Decision Support Systems, 39*(4), 549-562.

O'Leary, D. (2009). Wikis: "From each according to his knowledge". *IEEE Computer 41*(2), 34-41.

O'Reilly, T. (2005). What Is Web 2.0. Retrieved 1st August 2009, 2009, from http://oreilly.com/web2/archive/what-is-web-20.html

Rigby, B. (2008). *Mobilizing Generation 2.0: A Practical Guide to Using Web 2.0 Technologies to Recruit, Organize and Engage Youth*. San Francisco: Jossey-Bass.

Shuen, A. (2008). *Web 2.0: A Strategy Guide*. Sebastapol, CA: O'Reilly Media.

Stasser, G., Stewart, D., & Wittenbaum, G. M. (1995). Expert roles and information exchange during discussion: The importance of knowing who knows what. *Journal of Experimental Social Psychology, 31*(3), 244-265.

Sunstein, C. R. (2006). *Infotopia: How Many Minds Produce Knowledge*. New York: Oxford University Press Inc.

Suriwiecki, J. (2004). *The Wisdom of Crowds*. London: Abacus.

Szulanski, G. (1996). Exploring internal stickiness: Impediments to the transfer of best practices within the firm. *Strategic Management Journal, 17*(Special Issue, Winter), 27-44.

Tapscott, D., & Williams, A. (2006). *Wikinomics. How Mass Collaboration Changes Everything*. New York: Penguin Group.

Wegner, D. M. (1987). Transactive memory: A contemporary analysis of the group mind. In B. Mullen & G. R. Goethals (Eds.), *Theories of Group Behavior* (pp. 185-208). New York: Springer Verlag.

Wegner, D. M. (1995). A computer network model of human transactive memory. *Social Cognition, 13*(3), 319-339.

Wegner, D. M., Erber, R., & Raymond, P. (1991). Transactive memory in close relationships. *Journal of Personality and Social Psychology, 61*(6), 923-929.

Wittenbaum, G. M., Vaughan, S. L., & Stasser, G. (1998). Coordination in task-performing groups. In R. S. Tindale, L. Heath, J. Edwards, E. Posavac, F. B. Bryant, Y. Suarez-Balcazar, E. Henderson-King & J. Myers (Eds.), *Theory and Research in Small Groups* (pp. 177-204). New York: Plenum.